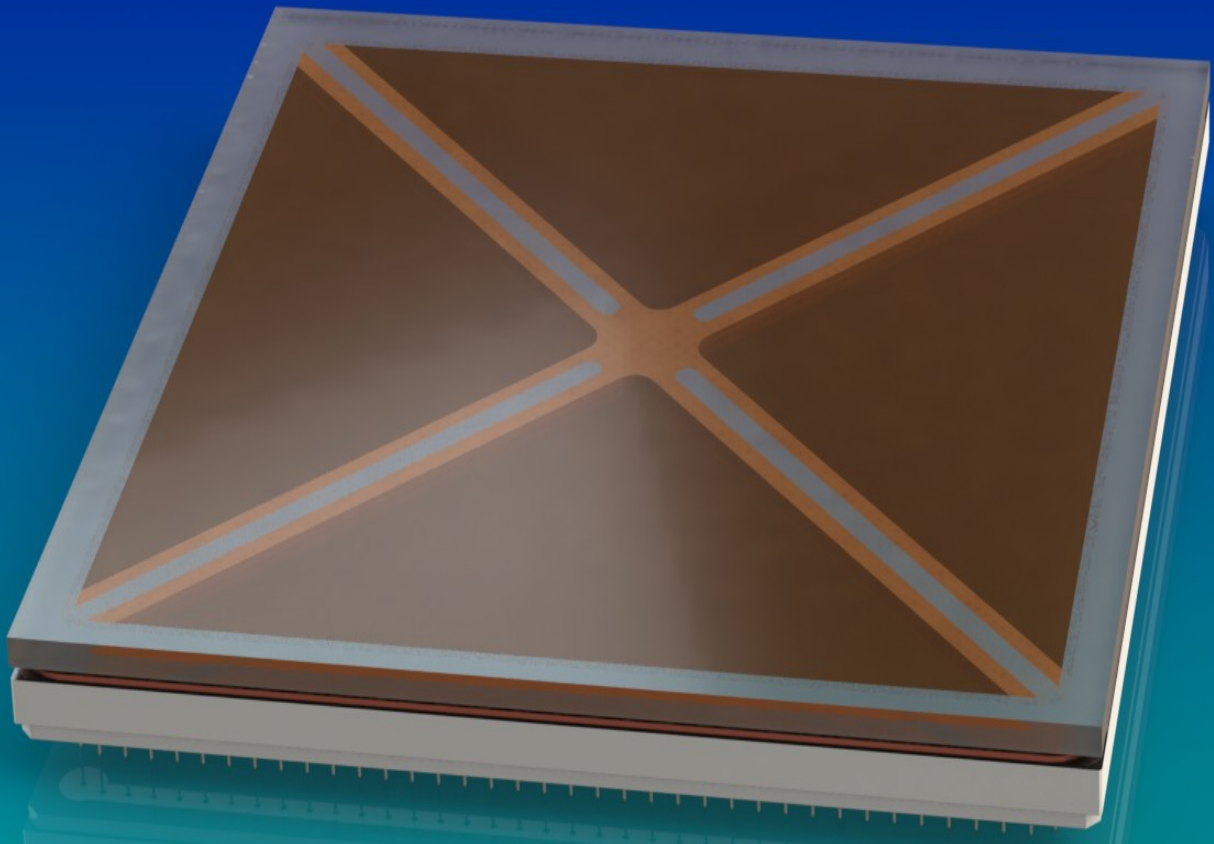
LAPPD Ceramic Package
Design, Flow, & Status

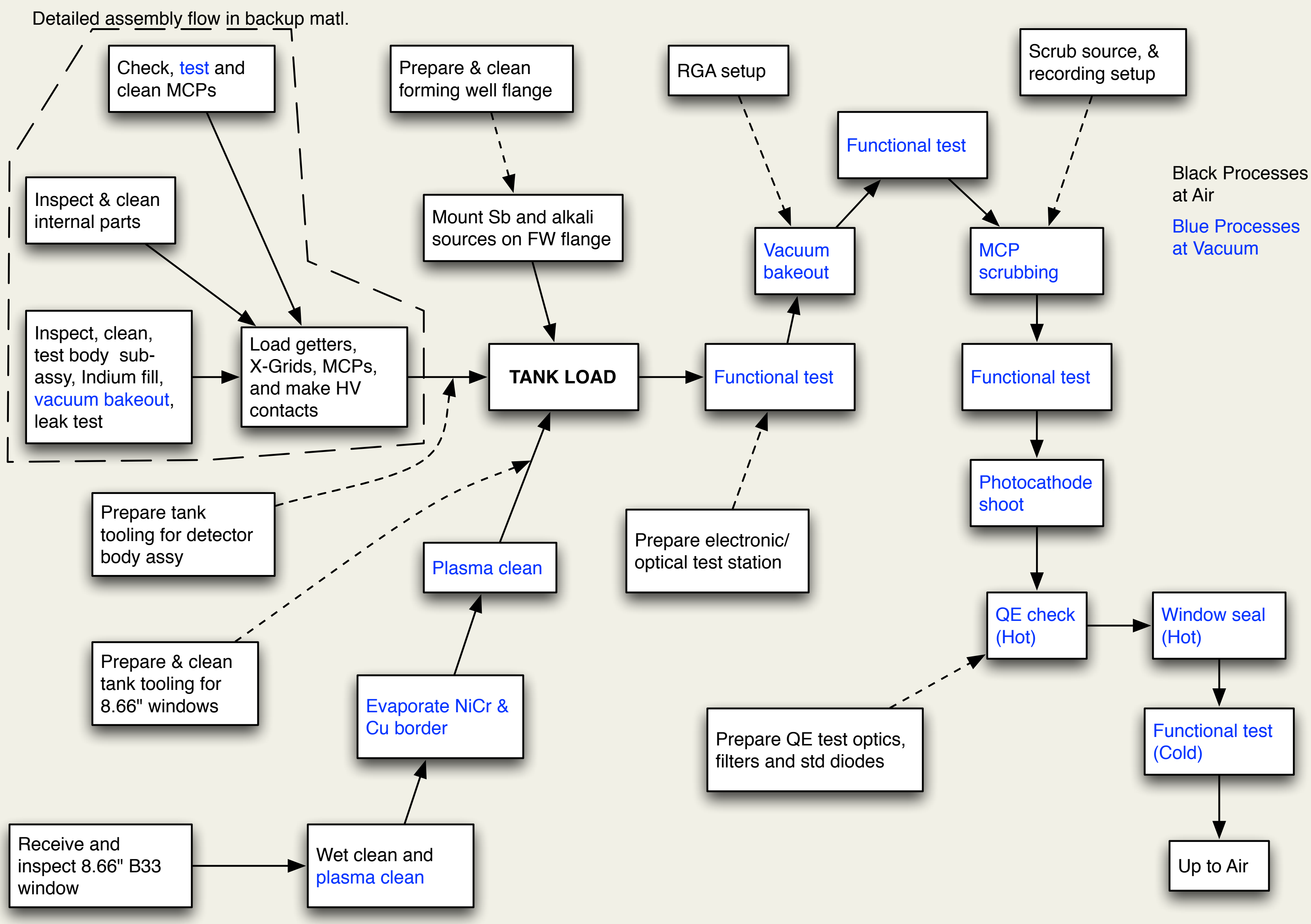


Jason McPhate & Oswald Siegmund

LAPPD DOE Project Review

18 December 2012

8” Tube Process Flow



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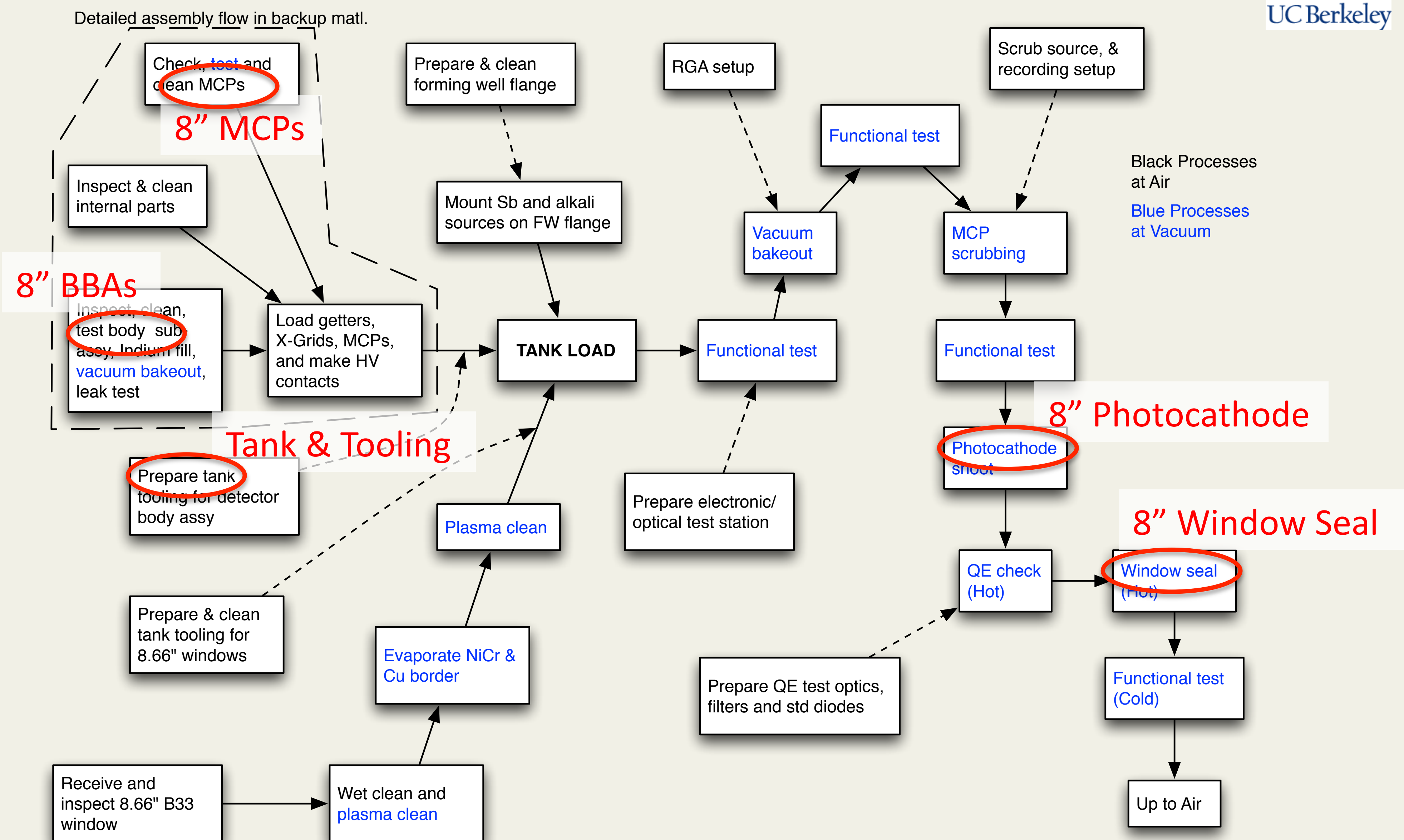
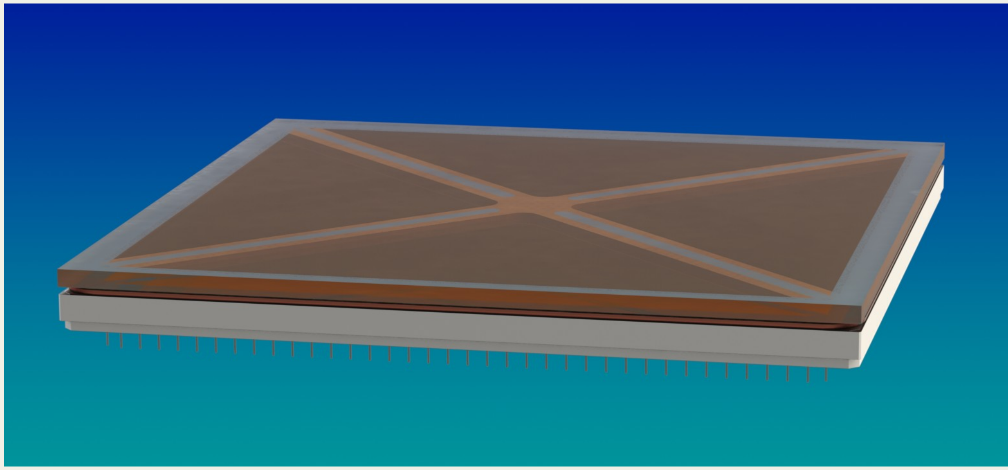


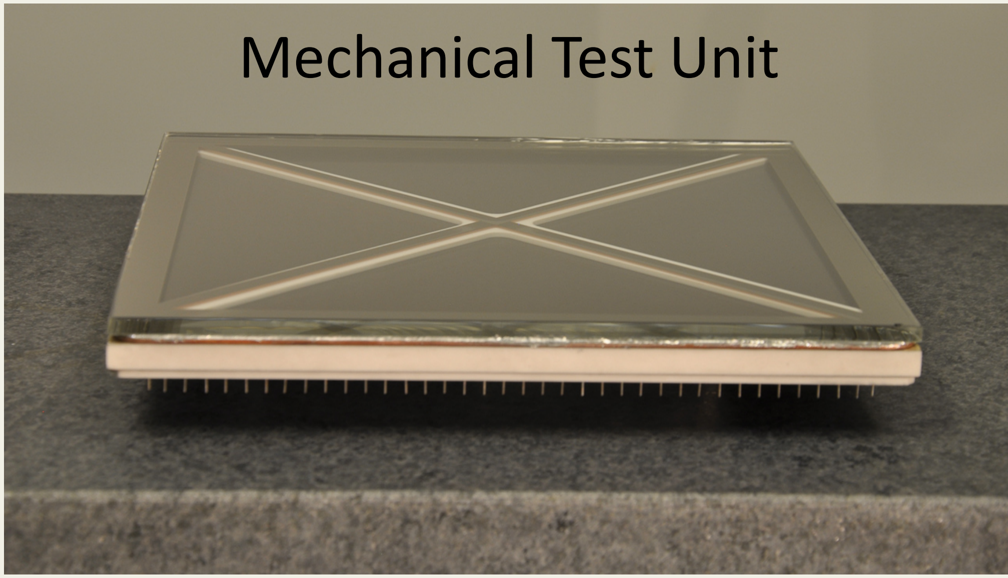
Critical Path Items / Enabling Technologies

- Leak tight 8” package (ceramic or glass)
  - He leak rates below detection limit (<10^{-10} std.cc/sec)
  - Compatible with tube processing; clean and robust
- 8” ALD MCPs (Wetstein and Siegmund talks on MCPs)
  - Beyond being functional, should be: robust, low outgassing, relatively uniform in gain/response, good lifetime behavior, and compatible with tube processing
- 8” Photocathode (Siegmund talk on photocathodes)
  - Needs to be compatible with tube process; transfer type PC, and robust to hot seal technique used at UCB
  - Good QE with reasonable uniformity over active area
- 8” Hermetic Seal
  - Occurs in vacuum (hot seal in the case of UCB)
  - Challenging because of its size and square shape
- Processing system
  - Large enough to handle 8” tube parts, small enough to fit within our existing oven
  - Internal tooling for manipulation and translation of 8” window
  - Flexibility to work with either ceramic or glass package (or future customized packages) with minimal modification

Ceramic Package Design Overview

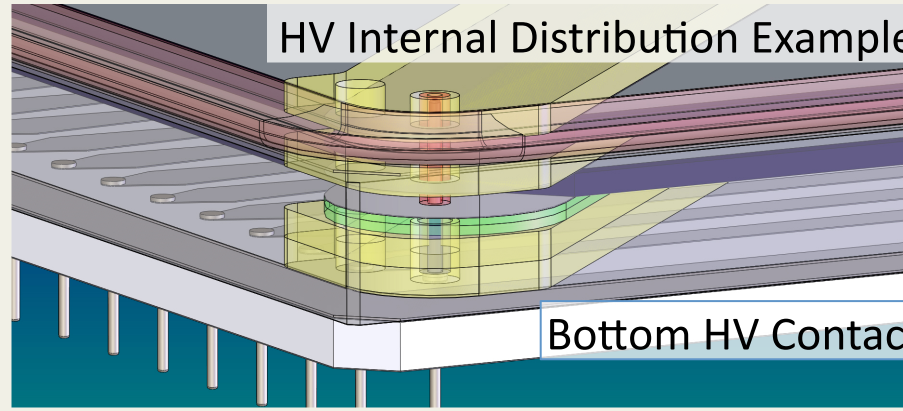
- Use "standard" sealed tube materials and processing
- Ceramic brazed body with Cu indium well
  - Signals and HV passed through the anode on Kovar pins
- 5mm thick borosilicate (Schott B33) window
- Na_2KSb bialkali photocathode
- Hot seal (InBi alloy)
- "X" shaped internal support structure
- 8.66" square, ~0.68" thick (including window)



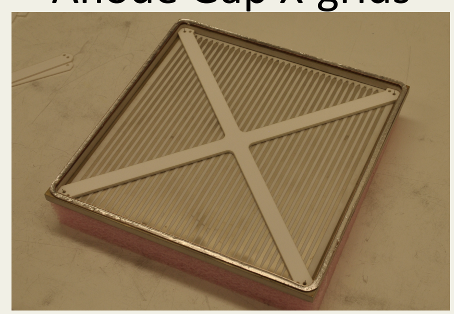


Internal Stack-Up

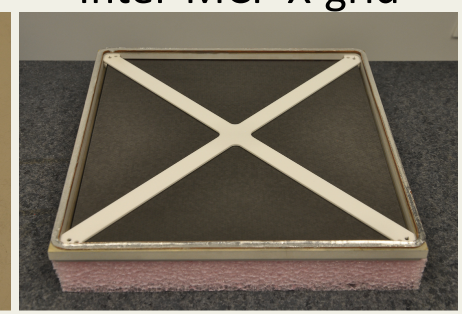
- Large area requires internal support structure to prevent window/anode cracking under atmospheric pressure load
- Desire to support without creating trapped spaces lead to “X” shaped support structures
- Combination of insulating ceramic X-grids and stainless X-shims
- X-grids isolate HV potentials while X-shims facilitate HV distribution (and stack height adjustment)
- Top X-grid serves to retain entire stack during processing
- Total internal stack height is .003” to .006” *below* the top of the Cu well – to ensure window seal

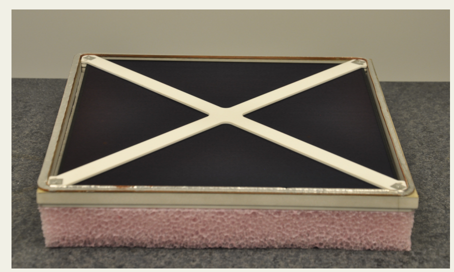


Anode Gap X-grids

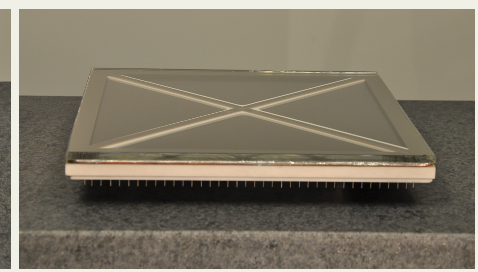


Inter-MCP X-grid





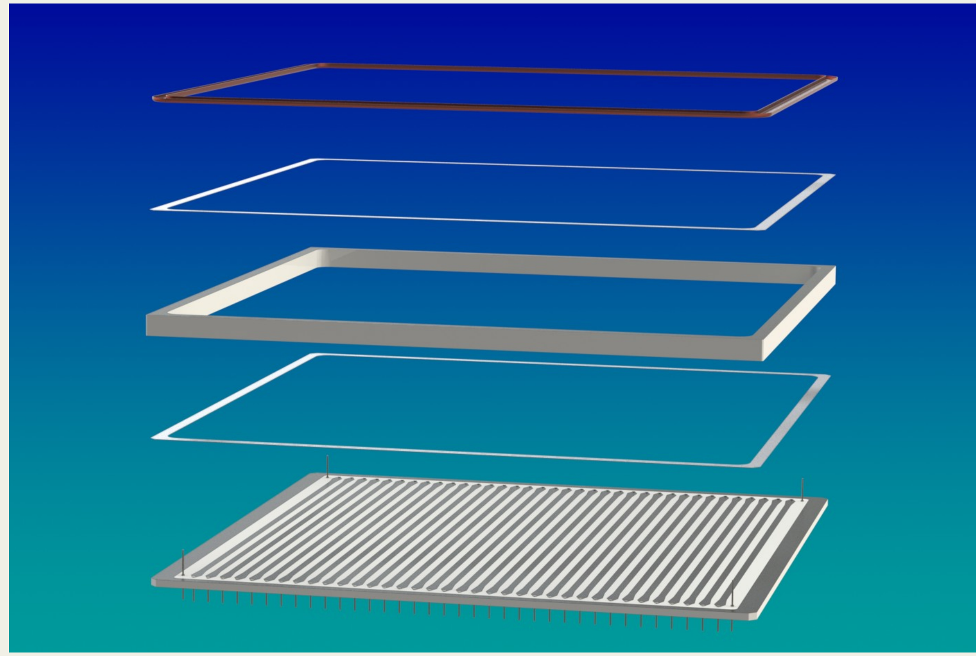
Cathode Gap X-grid

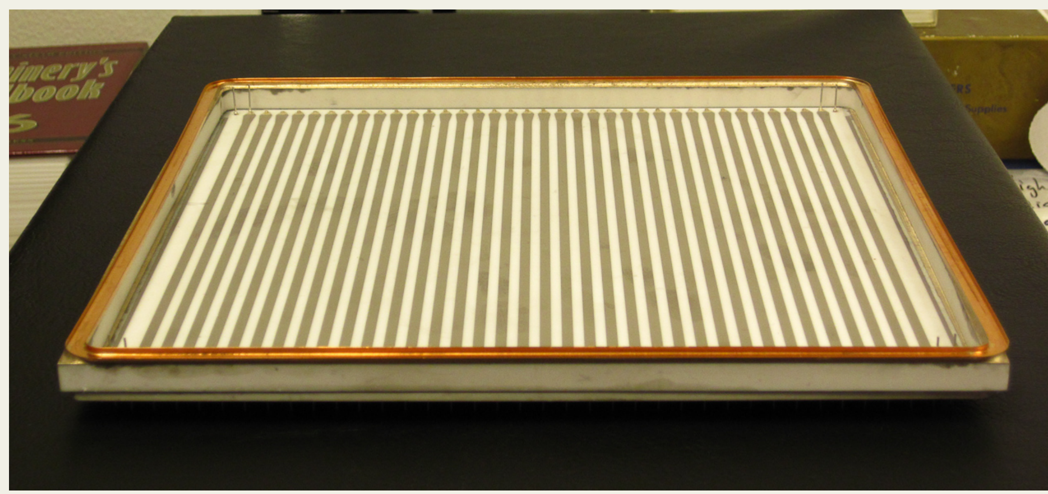


Mech. Test Unit

Ceramic Brazed Body Assembly

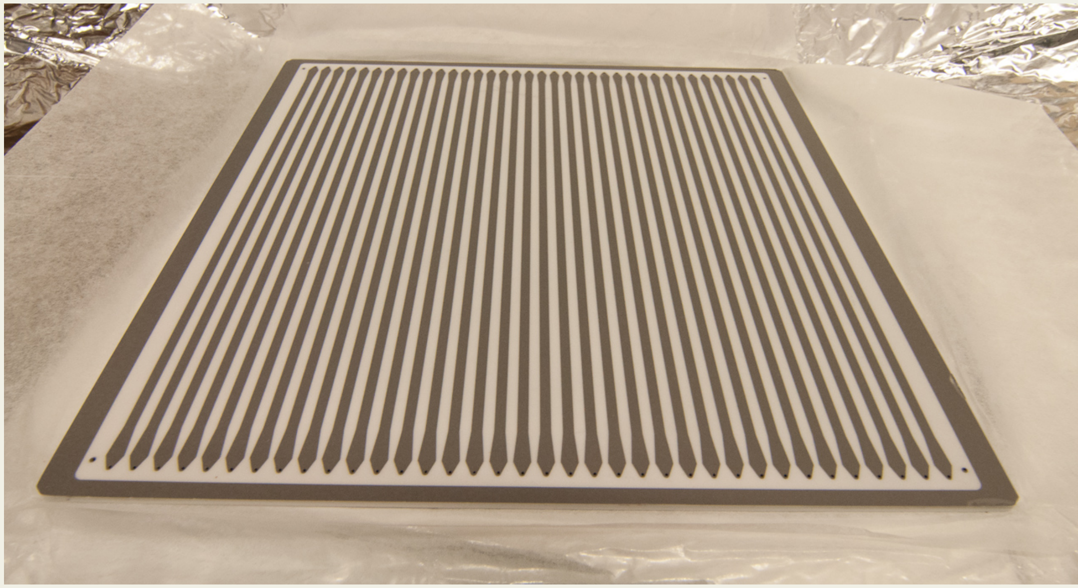
- All materials refractory or metal and proven for vacuum tube manufacturing
- High-temp metallized ceramic anode with Kovar feedthrough pins
- Ceramic sidewall frame
- Indium seal well is stamped from OFE copper (used for optimal indium wetting and ductility)
- Only two braze joints (save for the pins), using InCuSil braze alloy
- Large CTE mismatch between Cu and ceramic, but the Cu is very ductile and does not over-stress the ceramic

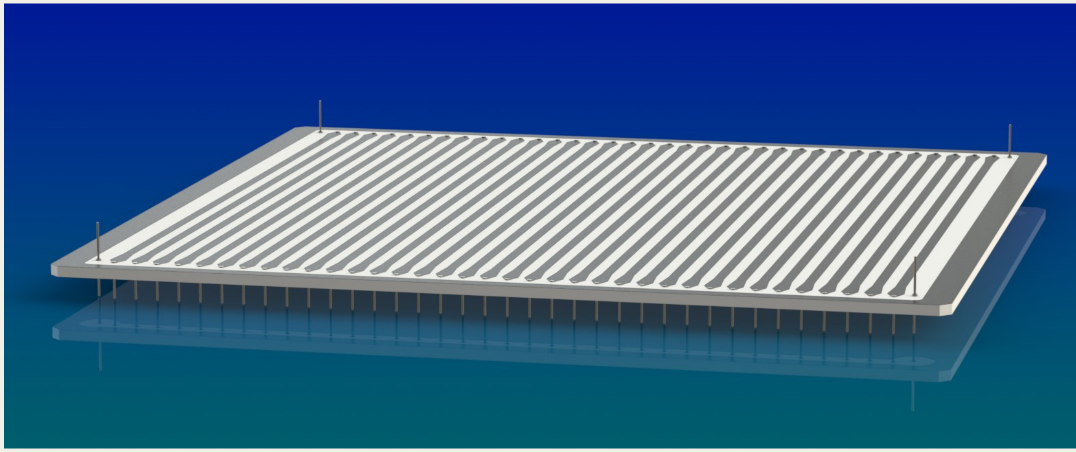




Ceramic Anode

- Substrate is .100” thick 96% alumina
- High-temp metallization
- 36 signal strips inside
- Solid ground plane outside
- Headed Kovar pins for signal and HV feedthrough
- HV pins are double-ended to distribute HV vertically within the tube – one in each corner
- Pins (76 in total) brazed into anode one of two ways
  - CuSil braze prior to body braze (current preferred method)
  - InCuSil braze simultaneously with body braze





A Brief History of the Ceramic Package Brazing Challenges

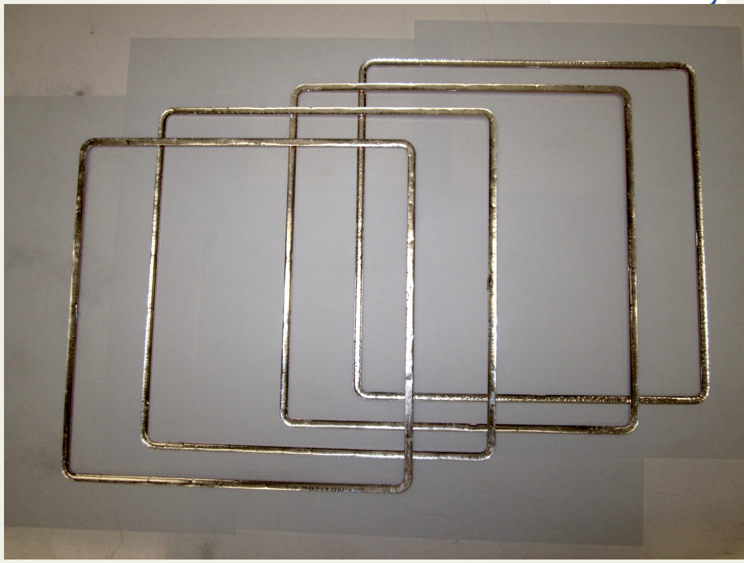
- Initial brazes were H_2 furnace, CuSil alloy with Kovar indium well resulted in cracked ceramic sidewall
  - Kovar a better (but not perfect) CTE match to alumina
  - Kovar too strong relative to ceramic → ceramic cracking
  - Also not getting complete braze alloy melt
- Switched to Cu well and InCuSil alloy
  - Still imperfect braze alloy melt
  - Not much helpful feed back from brazing vendor
- Switched braze vendor (vacuum brazing)
  - Much more responsive and proactively involved in process
- Two methods employed to-date at new vendor
  - All-in-one: Single InCuSil braze (pins to anode, anode and well to sidewall in one single braze process) – All assemblies leaked, particularly at pins.
  - Two-step: CuSil to braze pins into anode, then InCuSil to braze anode-sidewall-well assembly – Current process resulting in progressively better assemblies

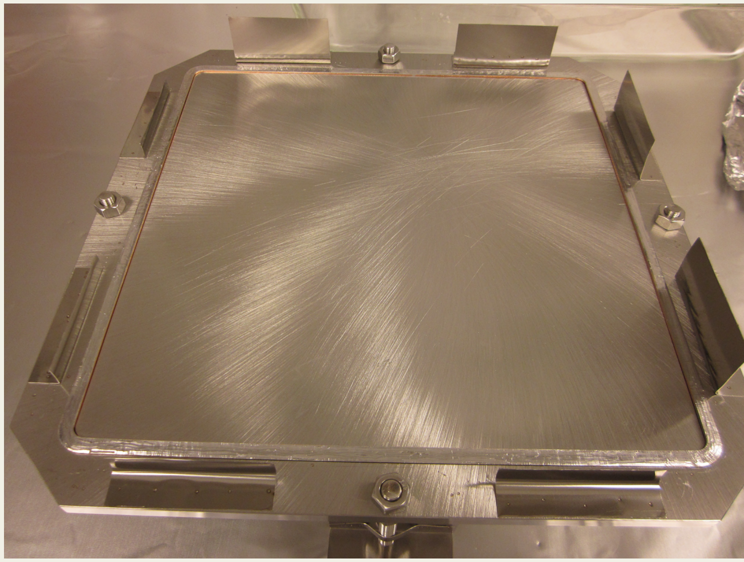
Two-Step Brazing Process

- Pins brazed into anode first
  - CuSil braze alloy – ~850°C process temperature
  - Stresses are minimal (pins are small) – Multiple re-braze runs possible
  - Mitigates risk at the incursion of increased expense
  - Three consecutive leak-tight anode-pin assemblies since switching to this method
- Body brazed using pre-pinned anode assembly
  - InCuSil braze alloy – ~750°C process temp, so no re-melt of pin braze CuSil alloy
  - Only one bite at this apple – Re-brazing seems to result in cracked parts (at least the one time we tried)
- Improved final assemblies
  - Prior to using the two-step process, assemblies had gross leaks – particularly at the pins
    - Several process modifications to the All-in-One braze did not significantly improve the results
  - The two stage process immediately resulted in assemblies that were much closer to leak tight and incremental progress has been made since
    - The first such assembly had four leaks in the 10^{-7} to 10^{-6} std. cc/sec regime
    - Latest has a single leak on one joint, other joint is leak tight
    - Further process modification is being made to resolve these smaller leaks

8” Hot Seal on Cu Well

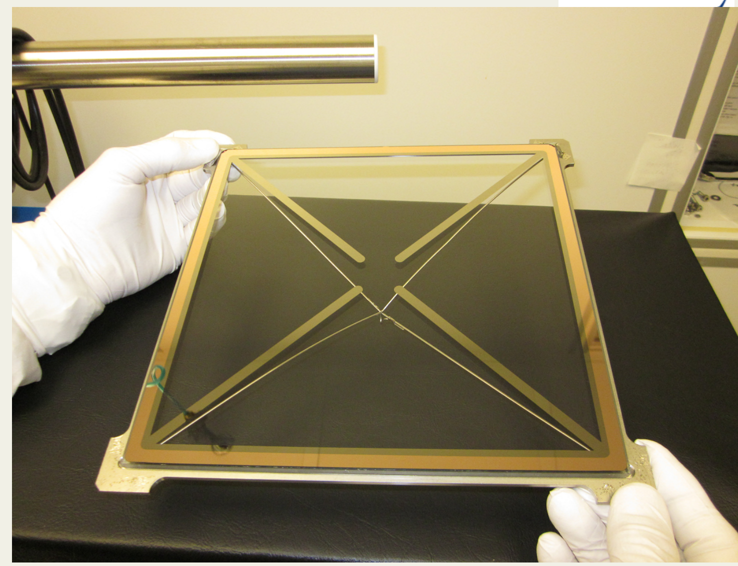
- Indium loaded into free Cu well (not brazed to ceramic wall)
- Scraped to remove surface oxides
- Vacuum baked to outgas indium and float internally trapped oxides
- Scraped again to remove oxides
- Installed in grooved plate (provided lateral, but not vertical constraint)

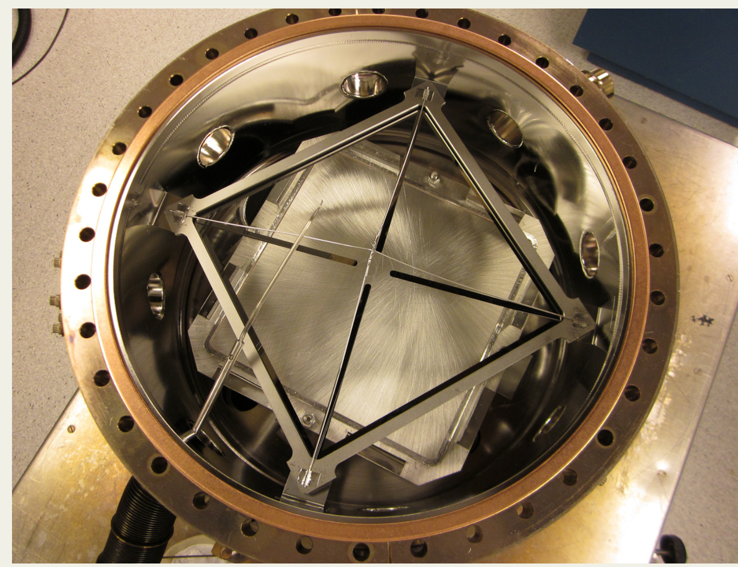




8” Hot Seal on Cu Well

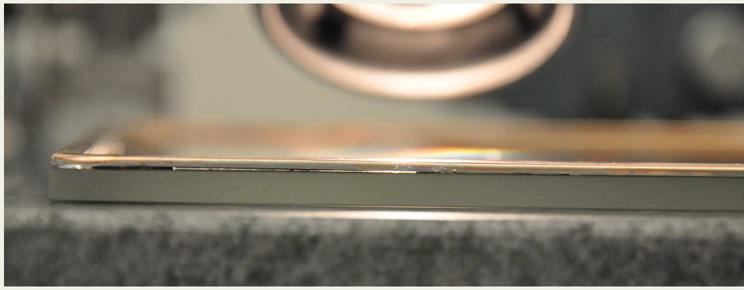
- 8.66” Borofloat B33 window evaporated with NiCr + Cu
- Installed into 8” photocathode test tank
- Heated in vacuum (160°C) and seal attempted
- Post-seal the chamber was cooled and vented
- Same process used during tube processing seal
- Good indium wetting to window (promising), but…

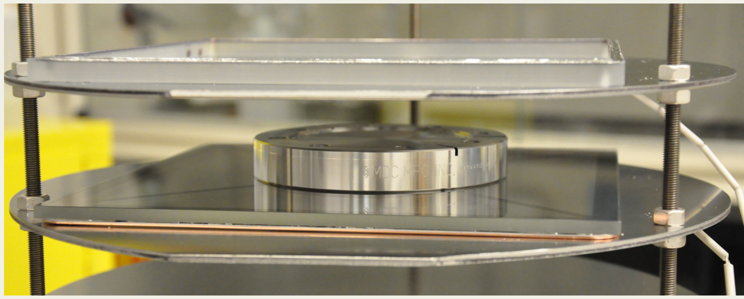


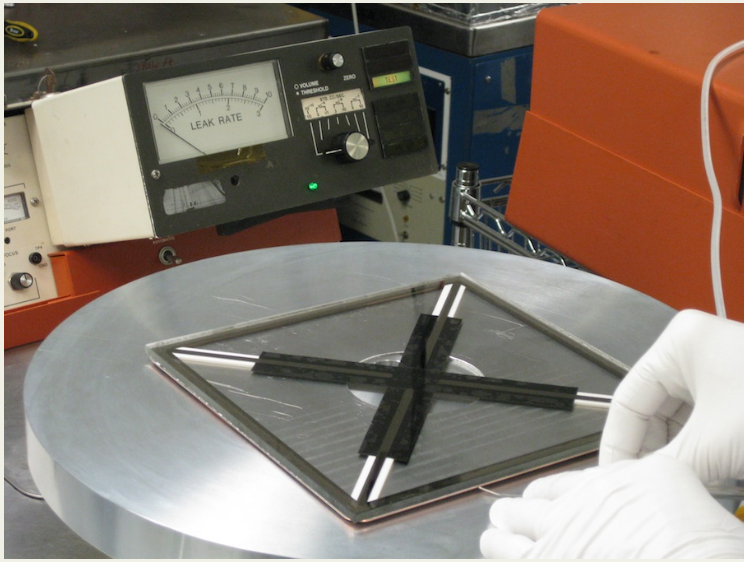


8” Hot Seal on Cu Well

- Copper deformed from flat → Significant gapping between window and copper
- Laterally restrained, but vertically free Cu well was not representative of the final assembly (where the Cu is affixed to the flat ceramics)
- Re-heated in vacuum *without* lateral constraint and with weight to re-induce flatness in Cu well.
- Resulting assembly is leak tight to $<10^{-10}$ std.cc/sec of He
- Window supported with X-grid during leak test
  - No window or X-grid breakage

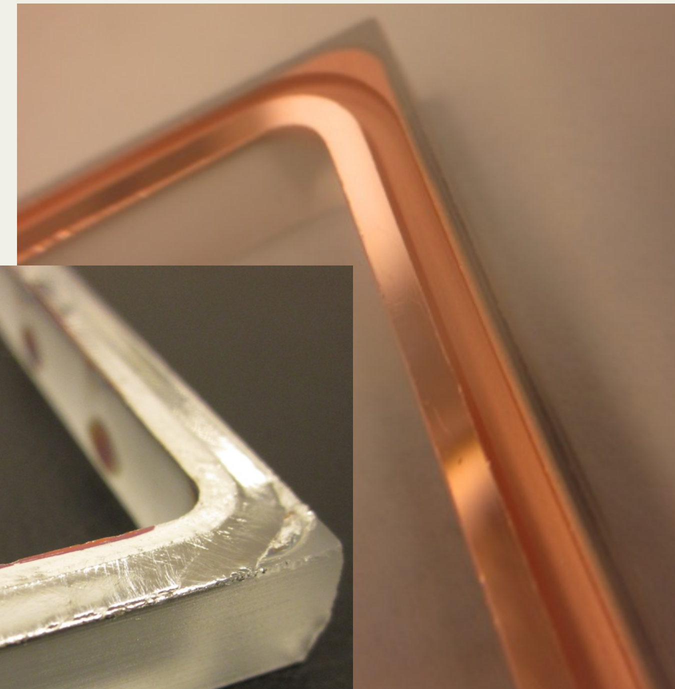


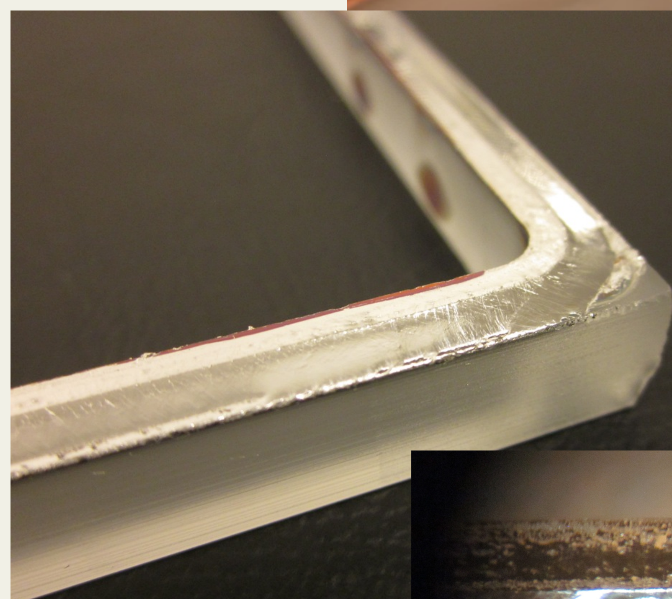


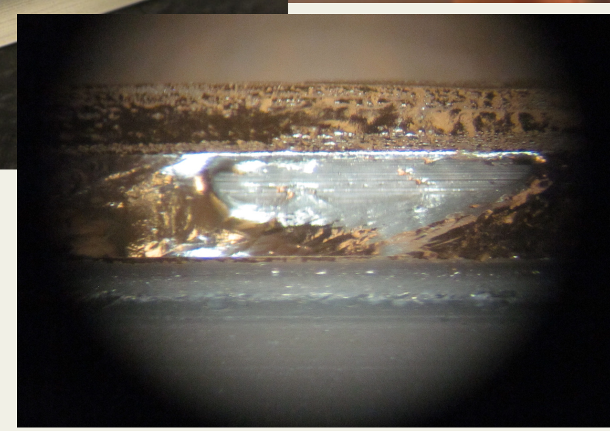


8” Grooved Glass Sidewall

- Groove machined into glass sidewall at UChicago
- NiCr and Cu evaporated into groove (~1000Å Cu)
- Indium filled and scraped
- Vacuum baked
- Cu scavenged by In during vacuum bake resulting in several pockets of bare glass
- Next article:
  - Better cleaning (plasma clean) prior to evaporation
  - Thicker NiCr and Cu to prevent loss of layer



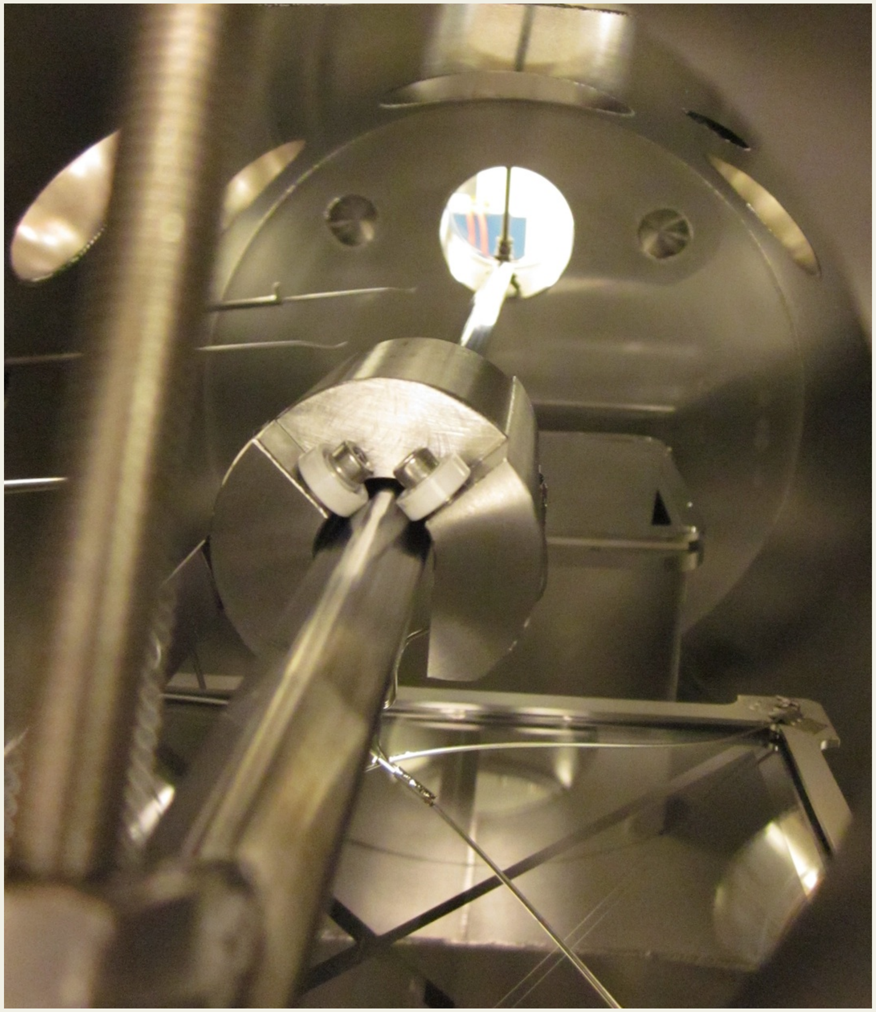




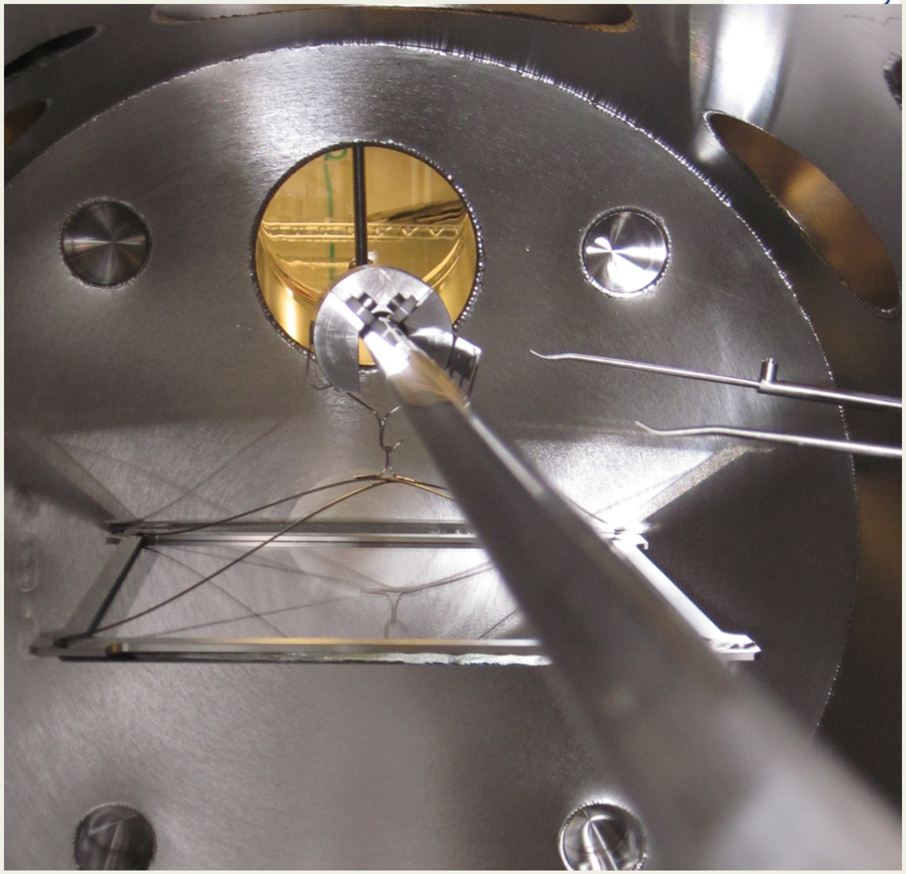
Large Process Chamber

- 8” sealed tube process chamber is fully commissioned
- Base pressure in the low 10^{-10} torr range
- Internal manipulation tooling complete and installed
- Photocathode deposition tooling complete and installed
- First 8” photocathode completed (process optimization next)
- Detector flange and support platform fabrication complete (need to make signal/HV contacts)

Large Process Chamber

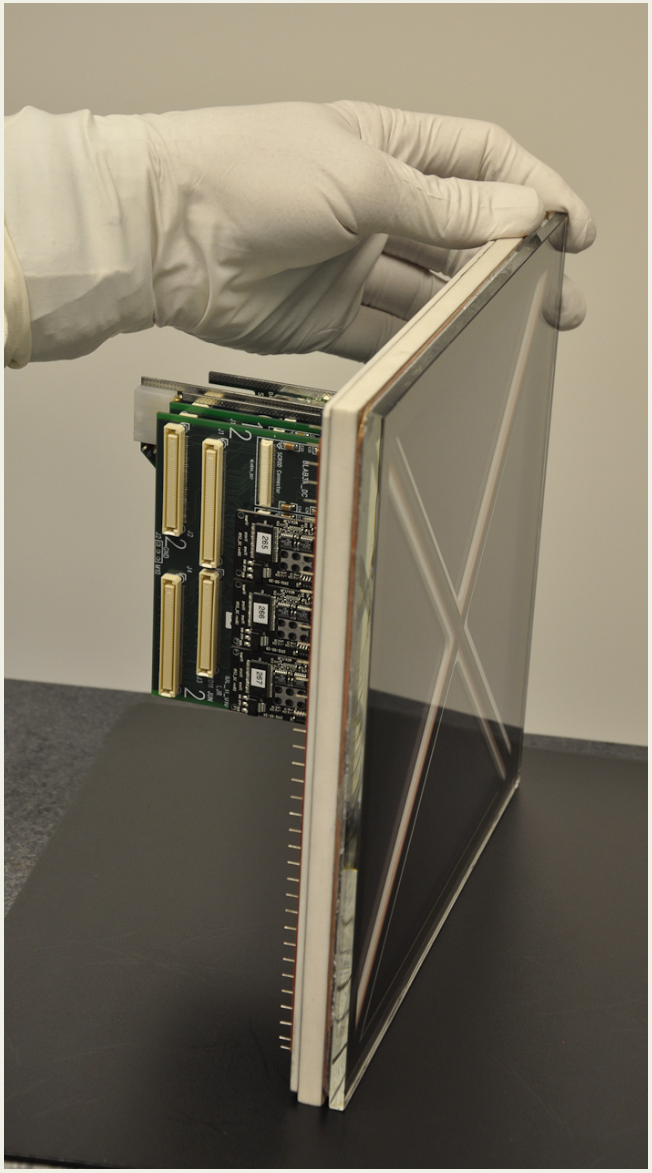


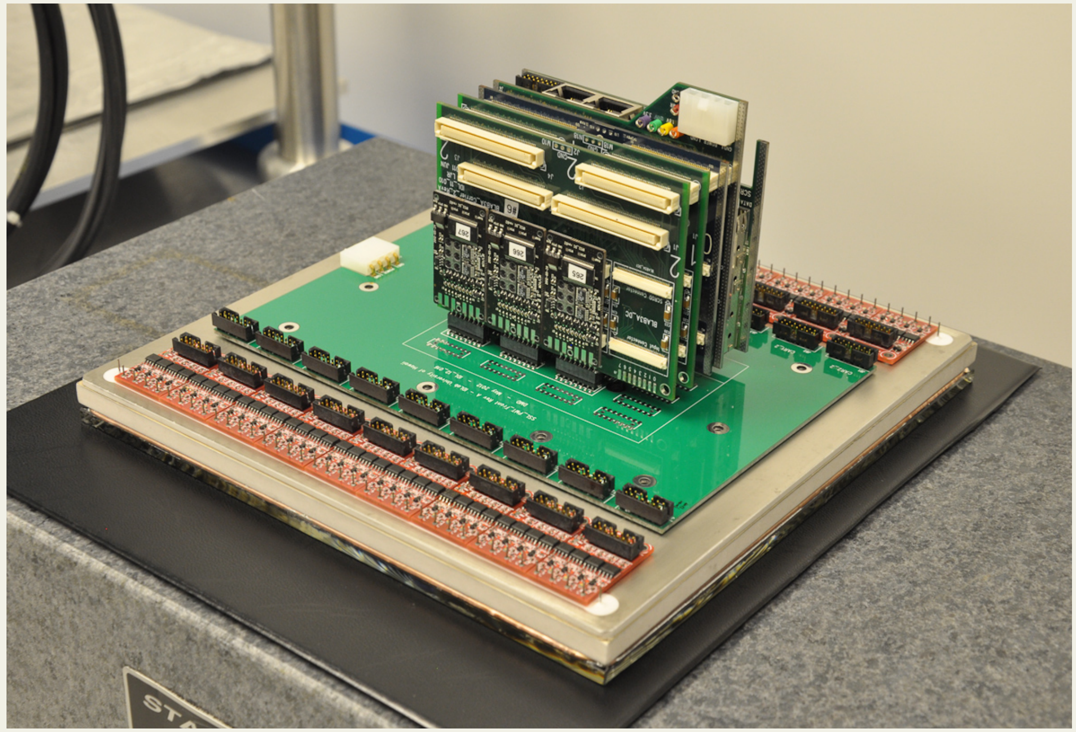
Looking down the window translation mechanism toward the photocathode forming well at the far end.



Window for 1st PC hanging on translation shuttle. Manipulation is performed with the wobble sticks at right.

Ceramic Package Electronics





- Readout electronics for the ceramic package provided by U of Hawaii (Varner talk on Electronics)
- Based on Belle-II iTOP readout electronics
- 18x 4-channel pre-amplifier boards
- 9x 8-channel analog to digital daughter cards
- 1x interface board and 1x power board
- Ready for testing
- Need ceramic package based demountable detector or tube to test

Near-Term Plans

- Fabricate brazed bodies from piece parts currently in process (six or seven more assemblies)
- Optimize photocathode in large process chamber
- Design & fabricate a brazed body based demountable detector for MCP & electronics testing
- Continue verification of glass package for processing in UCB system
- Begin tube fabrication upon arrival of first leak tight brazed body (or verification of glass package)

Longer-Near-Term Plans & Goals

- Continue production of sealed tubes at UCB
- Optimize ceramic package design
- Procure and process piece parts to support LAPPD 3 year goals
- Design and fabricate tooling for glass package processing
- Investigate potential cost saving modifications to the ceramic package (e.g., frit bonding the anode to a grooved ceramic sidewall)